RESEARCH ARTICLE

Prevalence and Correlation between MRI Findings and Outcome of Conservative Treatment in Primary Idiopathic Frozen Shoulder

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Abstract

Objectives: Primary idiopathic frozen shoulder (FS) causes pain and stiffness in the shoulder joint. Over time, this disease causes restriction of shoulder motion. We undertook this study to evaluate possible correlation of MRI findings with outcome of conservative management in FS.

Methods: A total of 65 cases participated in prospective cohort study. The correlation of MRI findings obtained before commencing the treatment with outcome of non-operative management (Mean of ROM, VAS, SST and OSS) was evaluated.

Results: Anterior extracapsular edema significantly correlated with FF, EXR, VAS (a) and OSS. The effusion in humeral side of axillary recess significantly correlated with ROM restriction in ABD, EXR. Capsular thickness of glenoid portion showed good significance with FF, ABD, VAS (a) and OSS. Increased thickness of CHL showed negative correlation with improvement of EXR (P=0.049) (r=-0.617). Thickening of IGHL showed negative correlation with improvement of ABD (p=0.005 r=-0.862) and FF (p=0.007 r=-0.831). Mean Height of Axillary recess (HAR) was 7.2mm (3.5-11mm). HAR showed negative correlation with VAS pain scale (P=0.036) (r=-0.682) and OSS (P=0.038) (r=-0.668)

Conclusion: Thickness of the joint capsule and effusion at the axillary fold are important factors for refractory frozen shoulder. We can recommend MRI for refractive cases and low threshold of expectation can be set for conservative management in patients with above findings.

Level of evidence: III

Keywords: Adhesive capsulitis, Conservative treatment, MRI, Primary idiopathic frozen shoulder (FS), Range of motion

Introduction

Primary idiopathic frozen shoulder (FS), also known as adhesive capsulitis, is a condition of uncertain etiology characterized by pain, restriction of shoulder motion, and considerable morbidity that occurs in the absence of intrinsic shoulder pathology.[1] Frozen shoulder involves global glenohumeral capsular contracture, significantly limiting passive and active movements in all planes. [2,3] It is a clinical diagnosis primarily reported in women between the ages of 40 and 60. Its incidence in the general population ranges between 2% and 5%, yet the definitive prevalence remains unknown. [4,5] Most clinicians follow the Lundberg classification of primary and secondary FS. The former arises idiopathically or in the context of metabolic diseases, such as diabetes mellitus, while the latter occurs secondarily due to previous trauma, surgery, or underlying arthritis. [6,7]

The use of radiographs for FS is common and may aid in distinguishing primary idiopathic FS from glenohumeral osteoarthritis or calcific tendinitis. [8] While several authors recommend magnetic resonance imaging (MRI) to rule out the secondary causes of adhesions, MRI's essential role in

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the diagnosis or management of FS has not been definitively established. [9] Substantial efforts have been dedicated to correlating MRI findings with clinical presentations and the staging of FS. [10,11] To the best of our knowledge, no report has compared MRI findings to treatment outcomes. Therefore, we undertook this study to assess the potential correlation between MRI findings and the outcome of conservative management in FS.

MRI findings in patients with FS encompass thickening of the coracohumeral ligament (CHL), thickening of the joint capsule in both the rotator cuff interval and the axillary fold (inferior glenohumeral ligament [IGHL]), and obliteration of the subcoracoid fat triangle, as well as extracapsular and axillary recess edema. [10,11] Studies have attempted to correlate these MRI findings with the clinical presentation of FS. [12,13] The results of these studies indicate that a few MRI findings can be correlated with the clinical presentation and staging of FS.

Idiopathic FS progresses through three stages: freezing (painful), frozen (adhesive), and thawing (recovery). [14,15] Although FS is a self-limiting disease with spontaneous recovery typically occurring within two years, it significantly impacts daily activities and disrupts patients' sleep at night, placing a substantial burden on healthcare services. The primary goal of treatment is to restore a pain-free, functional range of motion (ROM) as promptly as possible. [12] Conservative management, which includes rigorous physical therapy and local corticosteroid injections, has been reported to be highly successful in treating FS. [16,17] The arthroscopic capsular release is reserved for 10-15% of patients who remain functionally disabled despite several months of conservative management. [16,18]

Although several studies have examined the short- and long-term outcomes of both conservative and operative management in FS, [19–21] there is a lack of studies that correlate treatment outcomes with MRI findings. This study aims to determine if we can predict the prognosis of idiopathic primary FS and its response to conservative treatment based on pre-treatment MRI scans. Our hypothesis posits that the presence of certain MRI findings can be correlated with the poor outcomes of conservative treatment. If substantiated, MRI could be recommended as an essential screening tool in FS, allowing for a lower threshold of expectation in conservative management for patients with specific MRI findings.

Materials and Methods

This prospective cohort study included patients diagnosed with primary idiopathic FS in the freezing stage, with symptoms lasting between one and six months, and no evidence of secondary causes of stiffness, such as trauma or surgery. We utilized Codman's criteria, as modified by Zuckerman et al., for the diagnosis of FS. [22] These criteria involve the insidious onset of the disease, progressive pain in the deltoid region, sleep disturbances, and restriction of both active and passive shoulder motion to less than 50% of the normal range in at least two cardinal planes. [23] Considering the exclusion criteria, patients who had previously received treatment elsewhere through local injection and/or physiotherapy were not included in this study. Additionally, cases with symptom durations exceeding six months or those displaying signs of glenohumeral osteoarthritis or calcific tendinitis on plain radiographs, and/or concomitant rotator cuff tear detected in MRI were also excluded. Before undergoing an MRI, all patients underwent two orthogonal X-ray views of their shoulders.

Patient Data

The demographic form included details such as age, gender, body mass index (BMI), employment status, as well as medical, surgical, and drug histories. Patients completed two self-assessment questionnaires: the Visual Analogue Scale (VAS) for pain assessment and the Oxford Shoulder Score (OSS) for evaluating daily activities related to shoulder function. Passive shoulder ROM was measured by assessing forward flexion (FF), abduction (ABD), external rotation (EXR), and internal rotation (IXR). A single observer measured all ranges of motion using a goniometer scale. Internal rotation was measured using the hand-behind-back method against the level of the vertebrae.

MRI Findings

All patients underwent MRI before commencing the treatment in a single center with a specific shoulder MRI protocol using a 1.5 Tesla Siemens unit. This included obtaining T1-weighted (T1W), T2-weighted (T2W), and T2 fat-saturated coronal oblique images, along with Proton Density (PD) fat-suppressed images, as well as T1W axial and sagittal sequences. Two board-certified radiologists, one with over 10 years of experience and the other with 5 years of experience in musculoskeletal imaging, independently reported the MRI findings. The reporting was done according to a checklist prepared based on the review of the literature. [12,13,24,25] These radiologists were blinded to the patients' clinical evaluations. Since various studies have reported the same findings using different terminology, for the sake of clarity, a nomenclature that was less confusing was chosen and consistently maintained throughout the study. The following findings were evaluated: 1) Obliteration of the subcoracoid fat triangle, which was evaluated in the oblique sagittal plane of T1W images. It involves the obliteration of the area formed by the coracoid process, CHL, and joint capsule. The extent of high-signal-intensity fat replaced by low-intensity signal concerning subcutaneous fat determined whether it was absent, partial, or complete [Figure 1A]. 2) EXE: In the sagittal plane of the PD fat-suppressed MRI sequence, edema adjacent to the external capsule of the glenohumeral joint was assessed. Since the literature lacked a classification scheme for EXE, a qualitative ordinal assessment was performed, classifying it as absent, mild, or moderate [Figure 1B]. 3) CHL: The thickness of the CHL was measured at its thickest part in the PD fat-suppressed sagittal MRI sequence [Figure 2A]. 4) Effusion in the biceps tendon sheath: In the PD fat-suppressed axial MRI sequence, effusion in the long head of the biceps tendon sheath was qualitatively assessed as absent, mild, or moderate, based on the depth of fluid surrounding the tendon at the level of the humeral neck [Figure 2B]. 5) IGHL: The thickness of the IGHL in the mid-axillary recess was measured in the coronal T2W fat-suppressed MRI sequence [Figure 3A]. 6) Axillary recess: In the coronal

T2W fat-suppressed MRI sequence, the height and width of the axillary recess were measured at its most prominent portion [Figure 3B].

Figure 1. A 57-year-old male patient with clinical evidence of a right frozen shoulder. A: Sagittal oblique PD fat sat sequence showing obliteration of sub coracoid fat triangle. B: pericapsular edema is seen (arrow)

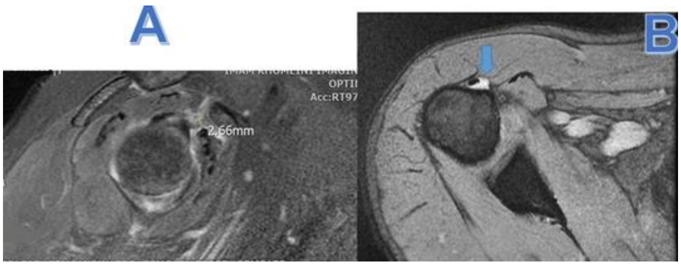

Figure 2. PD fat-suppressed sagittal MRI sequences A: measuring of Coracohumeral ligament (CHL) thickness. B: effusion in the long head of biceps tendon sheath

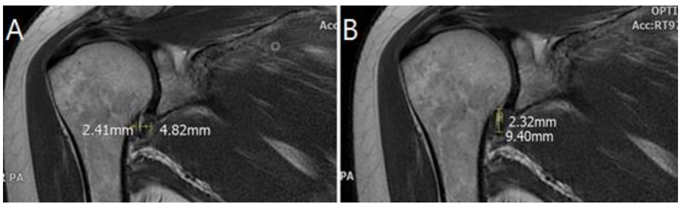

Figure3. Coronal T2 fat-suppressed MRI sequence A: thickness of inferior glenohumeral ligament in mid-axillary recess (glenoid and humeral side) B: measuring of height and width of axillary recess

Treatment Protocol

The study obtained approval from the Institutional Review Board and Ethics Committee prior to commencement. All patients underwent standard conservative treatment, including oral NSAIDs, local corticosteroid injections, and physical rehabilitation. [26,27] An ultrasound-guided intra-articular injection was administered by the senior author, a specialist orthopedic surgeon, once in the first week after diagnosis. The injection consisted of methylprednisolone-acetate 40 mg and 5 ml lidocaine 2%. Hydrodilatation was not attempted. Physical therapy involved progressive stretching exercises aimed at restoring ROM. Three sessions were administered weekly until a functional, pain-free ROM was achieved. Patients were evaluated before treatment, followed by a second evaluation at three months and a final evaluation at six months after treatment initiation.

Statistical Analysis

Statistical Package for Social Sciences (SPSS; version 22.0 for Windows) was utilized for data analysis. The correlation between treatment outcomes (difference in scores between the first and last evaluations) and the qualitatively assessed MRI findings was analyzed using the Kruskal-Wallis test. Statistical significance was noted if the P-value was less than 0.05. For quantitative MRI findings, the Pearson correlation coefficient 'r' was used. The 'r' value ranges from -1 to +1, where a value closer to +1 indicates a more positive correlation and a value closer to -1 indicates a more negative correlation. Significant correlations between quantitative MRI findings were further illustrated using scatterplot graphs.

Results

Demographics

From October 2017 to August 2019, our institution diagnosed 77 patients exhibiting clinical signs of primary FS. After detecting a concomitant rotator cuff tear on MRI, 12 cases were excluded. This led to the inclusion of 65 patients with primary idiopathic FS in the study, consisting of 38 females (58.5%) and 27 males (41.5%). The mean age was 56.1±16 years, with a mean BMI of 28.9 kg/m2. Comorbidities were observed in 30 patients, with 18 (27%) having type 2 diabetes mellitus, 7 (10%) with hypertension, and 5 (7.5%) with thyroid imbalance. Among the patients, 35 (53%) had left shoulder involvement, 28 had right-side involvement, and two patients reported bilateral FS.

Patient Evaluation

The mean ROM, VAS, and OSS scores of patients were assessed before treatment, as well as at a three-month and six-month follow-up, as shown in [Table 1]. In the final evaluation at the end of six months, 81.5% of the patients responded well to the treatment protocol, while the remaining 18.5% exhibited a poor outcome in terms of ROM restriction and/or the level of pain. Failure was defined as having less than a 50% improvement in ROM in at least two cardinal planes and/or a VAS pain score exceeding 5/10 even after six months of conservative treatment. Patients meeting these criteria underwent arthroscopic release for refractory cases.

Prevalence and Correlation

The prevalence of each qualitative and quantitative MRI finding was determined [Table 2], followed by a correlation analysis with patient improvement (the difference between the first and third evaluations) [Table 3]. The most prevalent MRI finding in our patients with FS was mild axillary recess effusion in the humeral portion, observed in 53.8% of the participants. This was followed by mild effusion in the biceps tendon sheath (49.2%) and mild anterior EXE (46.2%). If we exclude mild or moderate cases, the most prevalent MRI finding would be the obliteration of the subcoracoid fat triangle, which was seen in 83.1% of the patients, either partially or completely [Table 2].

Mild glenohumeral effusion in the axillary recess of the humeral portion was noted in 53.8% of the patients. The mean thickness of the CHL in patients was 3.6 mm (ranging from 2.0 to 5.5 mm). An increase in the thickness of the CHL was associated with a slight negative correlation with changes in VAS pain scores at rest (P=0.027) and EXR (P=0.049). The mean thickness of the IGHL was 4.0 mm (ranging from 1.6 to 7.0 mm). Thickening of the IGHL at the mid-axillary recess demonstrated a negative correlation with improvements in ABD (P=0.005, r=-0.862) and FF (P=0.007, r=-0.831). The mean height of the axillary recess (HAR) in patients was 7.2 mm (ranging from 3.5 to 11 mm). The HAR had a highly significant correlation with the difference in ABD (P=0.005). It also showed a moderately significant correlation with the difference in IXR (P=0.012) and OSS (P=0.018).

The HAR had lower significance with the difference in FF (P=0.040) and the VAS active pain scale (P=0.036). These findings suggest that HAR plays a significant role in shoulder-related outcomes, particularly in relation to ABD, IXR, and OSS. Moreover, clinical characteristics, such as age, gender, BMI, and comorbidities, including diabetes and thyroid imbalance, exhibited no correlation with treatment outcomes in our study.

Table 1. Mean ROM, VAS, and OSS scores of patients

	Parameter	Mean	Min-Max	Std. Deviation
First evaluation (Pre-treatment)	FF (degree)	90.46	30-120	15.045
	ABD (degree)	84.77	30-110	15.115
	EXR (degree)	7.69	0-20	6.794
	IXR	S2	L4-S3	-
	VAS rest	5.52	3-9	1.415
	VAS activity	8.4	5-10	1.367
	SST	2.17	0-5	1.409
	OSS	51.43	38-60	5.253
Second evaluation (F/u: Three months)	FF	114.92	40-150	20.32
	ABD	108.31	40-150	19.33
	EXR	26.46	0-60	11.65
	IXR	S1	L4-S3	-
	VAS rest	4.2	1-7	1.449
	VAS activity	6.77	3-9	1.423
	SST	4.05	1-8	1.615
	OSS	45.98	33-57	6.161
Third evaluation (F/u: Six months)	FF	137.08	50-170	24.983
	ABD	132.15	50-170	24.334
	EXR	46	0-80	19.349
	IXR	L5	L3-S2	-
	VAS rest	3.17	0-7	1.496
	VAS activity	5.12	1-8	1.546
	SST	5.66	1-9	1.77
	OSS	38.65	20-55	8.345

ROM: range of motion
VAS: Visual Analogue Scale
OSS: Oxford Shoulder Score
SST: Simple shoulder test
EXR: external rotation
IXR: internal rotation
FF: forward flexion

Table 2. Prevalence of MRI findings

Findings		Absent (%)	Mild (%)	Moderate (%)	Severe (%)
Glenohumeral effusion	Glenoid portion	44.6%	43.1%	12.3%	
	Humeral portion	30.8%	53.8%	15.4%	
Extracapsular edema	Anterior	24.6%	46.2%	23.1%	6.2%
	Posterior	46.2%	40.0%	13.8%	
Sub-acromial Bursitis		58.5%	41.5%		
Obliteration of sub coracoid fat triangle		16.9%	44.6%	38.5%	
Effusion in biceps tendon sheath		26.2%	49.2%	24.6%	

Findings		Mean	Min – Max	Std. Deviation
Capsular thickening	Glenoid portion	4.03	1.6 – 7.0	1.33
	Humeral	3.73	1.9 – 6.5	1.12
Axillary recess	Width	2.35	1.0 – 4.0	0.75
	Height	7.29	3.5 – 11.0	2.10
Coracohumeral ligament thickness		3.65	2.0 – 5.5	0.98

Table 3. MRI and outcome correlation after six months

	MRI Findings		FF	ABD	EXR	IXR	VAS(a)	VAS(r)	SST	OSS
1	**Glenohumeral effusion**	Humeral portion	0.610	0.003	0.001	0.112	0.022	0.346	0.095	0.040
		Glenoid portion	0.150	0.270	0.137	0.259	0.311	0.027	0.042	0.402
2	**Extracapsular edema**	Anterior	0.016	0.732	0.015	0.810	0.036	0.231	0.125	0.017
		Posterior	0.835	0.821	0.148	0.426	0.416	0.294	0.661	0.566
3	**Obliteration of subcoracoid fat triangle**		0.627	0.465	0.034	0.064	0.187	0.787	0.271	0.071
4	**Sub-acromial bursitis**		0.951	0.580	0.135	0.120	0.612	0.784	0.100	0.598
5	**Biceps tendon effusion**		0.480	0.131	0.207	0.758	0.937	0.811	0.420	0.334
6	**Coracohumeral Ligament thickness**		0.067	0.311	0.049	0.297	0.216	0.027	0.190	0.409
7	**Capsular thickness**	Glenoid portion	0.007	0.005	0.062	0.091	0.021	0.101	0.171	0.038
		Humeral portion	0.566	0.110	0.054	0.099	0.077	0.013	0.340	0.063
8	**Axillary recess**	Width	0.383	0.292	0.272	0.251	0.664	0.268	0.345	0.559
		Height	0.040	0.005	0.069	0.012	0.036	0.122	0.250	0.018

FF: Forward flexion/ ABD: Abduction/ EXR: External rotation/ IXR: Internal rotation VAS: Visual Analogue Scale/ SST: Simple shoulder test/ OSS: Oxford Shoulder Score

Discussion

Results from our study revealed no correlation between qualitative MRI findings and treatment outcomes. However, quantitative findings exhibited a significant degree of correlation with treatment outcomes following conservative management. The primary objective of treating FS is to swiftly restore pain-free, functional ROM. Recently, Hasegawa et al. reported that patients undergoing early surgical intervention experienced shorter symptom durations and achieved non-inferior clinical outcomes. [28] Consequently, our study aimed to predict patient outcomes based on pre-treatment MR images, thereby identifying cases where certain MRI findings suggest the need for early intervention. It should be noted that MRI findings can be challenging to correlate due to potential biases in reporting and interpretation. In our study, considerable effort was invested in selecting and analyzing MRI findings through an extensive literature review. Our study identified partial obliteration of the subcoracoid fat triangle in 44% of patients and complete obliteration in 38%. This finding, observed as an area of high-signal-intensity fat confined by the joint capsule, coracoid process, and CHL, is more commonly detected in the initial stages of FS, possibly due to inflammatory changes. [7,29] Despite this, previous studies have not definitively correlated obliteration of subcoracoid fat triangle (OFT) with clinical impairment, and our results are in line with this lack of correlation.

Extracapsular edema was mild in 46% and moderate in 23% of the shoulder scans in our study. This finding, previously referred to as pericapsular edema, has been noted in FS, with a prevalence ranging from 32% to 47%. [13] While some studies have associated increased EXE with limitations in ABD and EXR in late-stage FS, our study did not establish any correlation between EXE and treatment outcomes. [30]

Choi et al. reported that effusion in the biceps tendon sheath is one of the useful MRI parameters for diagnosing FS. [31] Emig et al. proved that FS presents with more effusion (mean 1.6 cm3) than asymptomatic volunteers (mean 1.5 cm3); however, the difference was not significant. [9]

Effusion in the biceps tendon sheath was evaluated as mild or moderate in our cohort, with 39% exhibiting mild and 24% showing moderate effusion. While studies have reported this finding as a useful MRI parameter for diagnosing FS, our study could not establish a correlation between effusion in the biceps tendon sheath and treatment outcomes.

The mean thickness of IGHL in our study was 4.0 mm, consistent with literature reporting a range of 3.1 to 4.5 mm in patients with FS; however, authors have used different nomenclature for this same finding (capsular thickness in axillary recess). [10,18,19] In asymptomatic volunteers, IGHL was found to be 2.0 to 3.8 mm. [9,18] Our results indicated that increased IGHL thickness negatively affected improvements in ROM, especially in ABD and FF. This finding aligns with previous studies that have shown the negative correlation of IGHL with EXR and IXR in patient presentation. [10]

The mean HAR in our study was 7.2 mm, in line with similar studies (Chellathurai and Park was 6.8 mm and 7.1 mm). [18,19] Reduced HAR due to contracture was associated with less improvement in pain and higher disability, as indicated by a higher OSS at the end of the conservative treatment. Park et al. showed a negative correlation between HAR and pain intensity. [19]

In asymptomatic volunteers, CHL width was reported to be between 1.7 and 4.4 mm. [21] several studies have suggested that the thickening of CHL on MRI is indicative of adhesive capsulitis. [9,32] The mean thickness of CHL in patients with FS was reported to be 3.2 to 4.9 mm. The authors have indicated the profound effect of the thickness of CHL on ROM. [21,10] In our study, the mean CHL thickness was 3.6 mm, and patients with thickened CHL showed less improvement in EXR upon conservative management.

Since its introduction in 1934 by Codman, FS has been characterized as difficult to define, treat, and explain. [33] While the exact pathological mechanism remains a topic of debate, both synovial proliferation and capsular fibrosis are implicated. [24] Nevertheless, capsular changes are thought to be present in all phases and responsible for the reduced ROM clinically found in FS. [10,32] The findings in this study reinforce the importance of capsular pathologies, particularly contracture and inflammation at the axillary recess rather than the rotator interval, in influencing the severity of FS.

The thickness of the joint capsule at the axillary fold of the IGHL and the height of the recess are important factors for refractory FS. Various studies have reported the association between MRI findings and clinical features and staging of adhesive capsulitis. To the best of our knowledge, this is the first study correlating MRI findings with treatment outcomes of conservative management in patients with primary idiopathic FS.

Limitations

Despite the significance of the findings, this study suffers from some limitations. First, as there is no universally defined method for measuring MRI findings in patients with FS, we opted for a qualitative ordinal measurement for some of the findings. Moreover, as we focused primarily on treatment outcomes, the correlation between MRI findings and clinical staging was not studied. Finally, the MRI of the contralateral shoulder was not included in the study for comparison of the findings. Overall, different studies chose various methods for assessing the ROM. Specifically, some measured IXR with ABD and rotation. [10] We measured it with the hand-behind-back, against the level of the vertebrae, which is considered a more standard measure of IXR.

Conclusion

In this prospective study of patients with idiopathic primary FS, MRI findings were correlated with poor outcomes following conservative management, concerning ROM, as well as the thickness of IGHL and CHL. Improvements in function and pain were associated with HAR. The question of recommending MRI for patients with FS remains controversial and debatable. However, we can recommend MRI for refractive cases, and a low threshold of expectation can be set for conservative management in patients with the above conditions.

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